Representing Sound Structure: Evidence from Aphasia

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1 Introduction

Jakobson (1941/1968) famously argued that the same principles of phonological complexity – markedness – constrain the cross-linguistic distribution of sounds, the acquisition of sounds, and the loss of phonological abilities in aphasia. With respect to aphasia, empirical tests of this claim have given mixed results (Béland et al. 1990, Blumstein 1990, Romani & Calabrese 1998). The work presented here supports Jakobson's claim, providing evidence that aphasic speech is constrained by markedness as formalized in Optimality Theory (OT, Prince & Smolensky 1993/2004) This paper explores the phonological errors of VBR, an English speaking aphasic individual who suffered a stroke at age 51, six years prior to the onset of the current study. VBR has particular difficulty with complex structures such as onset consonant clusters, as shown in the obstruent-sonorant examples in (1)[1]:

(1) *Representative errors of VBR's onset cluster production*

Target	*Response*
bleed	[bəlid]
glue	[gəlu]
prune	[pərun]
crab	[kəræb]

Within the framework of OT, this pattern reflects a ranking in which the markedness constraint banning complex onset clusters (*CLUSTER) dominates the faithfulness constraint prohibiting vowel epenthesis (DEP-V). Given that the repair of the marked cluster is epenthesis, it requires that the constraint against consonant deletion (MAX-C) outranks DEP in VBR's grammar.

The ranking *CLUSTER, MAX-C ≫ DEP-V predicts that all consonant clusters will be resolved via vowel epenthesis. This prediction is incorrect; there is an asymmetry in the repair of obstruent-glide clusters: clusters with /w/ are resolved via epenthesis, whereas clusters with /j/ are resolved via /j/-deletion. Importantly, consonant-/j/ sequences are <u>never</u> resolved via epenthesis. Examples are provided in (2):

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[1] The production errors occur in a variety of elicitation tasks (e.g., picture naming, repetition, oral reading), suggesting that the errors are the result of a phonological deficit and not due to an input deficit. Additionally, the productions of the inserted vowel were the focus of an ultrasound imaging study designed to address the issue of whether these errors are categorical epenthesis or whether they are the result of 'gestural mistiming' (as in Davidson 2003, and Hall 2003). The results of that study (see Buchwald, in preparation) suggest that the inserted vowel is the result of epenthesis, a categorical repair of marked phonological structure.

(2) *Asymmetry in consonant-glide sequence repairs*

a. Consonant-/w/ sequences
queen → [kəwin]
quote → [kəwoʊt]

b. Consonant-/j/ sequences
cute → [kut]
music → [musɪk]

In this paper, I argue that the aphasic speech production patterns presented in (1) and (2) are indicative of different sound structure representations for tautosyllabic consonant-/j/ sequences compared to other obstruent-sonorant sequences in American English. In particular, section 2 presents the argument that the /j/ in tautosyllabic consonant-/j/ sequences surfaces as part of a diphthong with the following vowel (following Davis & Hammond 1995, also see Barlow 1996, 2001). Section 3 focuses on the phonotactic distribution of sequences with [u]; VBR's data are used to support the claim that /ju/ sequences following a coronal sonorant (e.g., *menu* [mɛnju]) have heterosyllabic consonants, and /j/ surfaces as a singleton consonant onset. Section 4 provides a comprehensive Richness of the Base (Prince & Smolensky 1993/2004) analysis of post-consonantal /j/ in American English.

2 Tautosyllabic consonant-/j/ sequences

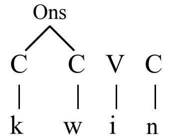
In this section, it is argued that tautosyllabic consonant-/j/ sequences are not consonant clusters, and that /j/ forms a vocalic diphthong constituent with the following vowel. The evidence presented in support of this claim comes from phonotactic data (section 2.1) and VBR's productions (section 2.2), and builds on previous work by Davis and Hammond (1995).

2.1 Phonotactics of consonant-glide sequences

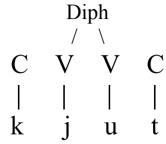
Davis and Hammond (1995) note an asymmetry in the distribution of vowels in tautosyllabic consonant-glide-vowel sequences. When the glide is /w/, there are few restrictions on the identity of the vowel (e.g., *queen, quote, quack*, *quaff).* This type of phonotactic distribution suggests that there is no constituency relationship between /w/ and the following vowel. However, when /j/ follows a tautosyllabic consonant, /u/ is the only vowel that follows (*e.g., cute,* *[kjit], *[kjoʊt], *[kjæt], *[kjɑt]). Davis and Hammond argue that this phonotactic restriction suggests a constituency relationship between /j/ and /u/.

Additional evidence that tautosyllabic consonant-/j/ sequences do not form a constituent comes from the relative lack of restrictions on the consonant compared to other clusters. Whereas the first consonant in other onset consonant clusters (e.g., /Cw/) is limited to obstruents (*[.mw__], *[.nw__]), /j/ may be preceded by a tautosyllabic /m/, as in *music* ([mjusɪk]). The phonotactic restrictions thus favor an account in which /j/ is a constituent with /u/, and not with the preceding consonant; there are few restrictions on the preceding consonant[2] and strong restrictions on the following vowel. Davis and Hammond argue that the /ju/ sequence form a vowel diphthong. The structural representation of consonant-w clusters and consonant-/ju/ sequences are depicted in (3a,b)[3]:

(3) a. Representation of [Cw] as cluster



b. Representation of [j͡u] as diphthong



[2] There are restrictions with respect to the place of articulation of the preceding consonant. /j/ does not appear following word-initial coronal consonants. See section 3 for a discussion of coronals and /j/.

[3] It is worth noting that Davis and Hammond (1995) argued that /ju/ is an *underlying* diphthong (/ɪu/) and that a gliding rule causes the onglide to surface as a glide. Within OT, this distinction is not meaningful; given Richness of the Base, for a structural difference to be phonologically relevant it must be a surface distinction.

The representation in (3b) accounts for the phonotactic restrictions on vowels following apparent consonant-/j/ sequences, as [j͡u] is a vowel diphthong, and [j͡u] is the only diphthong for which /j/ is the onglide.[4] The well-formedness of (3b) also explains the lack of consonantal restrictions on tautosyllabic consonant-/j/ sequences: this consonant is a singleton onset, so it is relatively unrestricted (see footnote 2 and section 3 for discussion). There is no restriction on the vowel in a form such as (3a), which accounts for the lack of vowel restrictions following consonant-/w/ sequences.

2.2 VBR and tautosyllabic consonant-glide sequences

The representational distinction in consonant-glide sequences shown in (3a) and (3b) helps to account for the differences in VBR's production of tautosyllabic consonant-glide sequences. VBR produces forms that have consonant-/w/ onsets with a schwa epenthesized between the two consonants (e.g., *queen* → [kəwin]). However, she systematically deletes the /j/ in forms with tautosyllabic consonant-/j/ sequences (e.g., *cute* → [kut]). The argument presented in the introduction is that epenthesis in the [Cw] cluster follows from the ranking *CLUSTER, MAX-C ≫ DEP-V. However, forms such as [kj͡ut] are repaired via deletion and not epenthesis, which requires that DEP-V ≫ MAX-V in VBR's grammar. This ranking does not affect cluster simplification (e.g., *bleed* → [bəlid]), as deleting a vowel is not a possible repair of these sequences. Forms that contain the rising diphthong [j͡u] violate *RISING, a constraint in the *COMPLEX family that prohibits rising diphthongs. This constraint is elevated in VBR's grammar (as are all constraints in the *COMPLEX family), and the rising diphthong is 'repaired' to the singleton vowel [u] given the ranking of faithfulness constraints described above. The difference between VBR's grammar and standard American English is discussed in section 4.

3 Phonotactics of [u] and [j͡u]

To understand the appearance of the diphthong [j͡u] in American English, it is important to consider the distributional facts of [u]. This section examines the appearance of [u] and [j͡u] in several post-consonantal contexts.[5] Each subsection focuses on a different class of sounds that may precede these vowels: non-coronals (section 3.1); alveolar sonorants (section 3.2); and alveolar obstruents (section 3.3). For each consonant, the distribution of [u] and [j͡u] will be considered in both prominent syllabic positions (stressed, initial) and in non-prominent syllabic positions (post-tonic). The main goal of this section is to establish the descriptive generalization regarding [u] and [j͡u] for which a Richness of the Base analysis will be provided in section 4.

3.1 Non-coronal consonants

In initial and stressed syllables, [u] and [j͡u] are contrastive following non-coronals, as shown in the examples in (4).

(4)	a.	*coot*	[kut]	*cute*	[kj͡ut]
	b.	*food*	[fud]	*feud*	[fj͡ud]
	c.	*bubonic*	[bubɑ́nɪk]	*bucolic*	[bj͡u.kɑ́.lɪk]
	d.	*movie*	[mú.vi]	*music*	[mj͡ú.zɪk]

(4a,b) contain minimal pairs for monosyllabic words with [u] and [j͡u] as stressed vowels, and (4c) shows that [u] and [j͡u] contrast in unstressed initial syllables as well. The pattern in post-tonic syllables is different: [u] does not follow non-coronals in post-tonic syllables (e.g., *[kǽl.ku.leɪt]).[6]

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[4] It is worth noting that [j͡u] is the only rising diphthong (e.g., diphthong with an onglide) in American English.

[5] Although not a focus of this paper, it is noteworthy that [u] is not typically word initial (e.g., *Europe, Uganda*). The exceptions to this generalization tend to be loan words (e.g., *oolong*) and onomatopoeia (e.g., *oops*).

[6] In many registers of American English, the word *calculate* may be said to contain a reduced vowel in the post-tonic syllable (i.e., [kæl.kjə.leɪt]). However, the main issue that affects the argumentation in this paper is whether

3.2 Coronal Sonorants

In stressed and initial syllables, [u] (and not [j͡u]) always follows coronal sonorants [l, n, r] in American English words. Examples of licit and illicit forms are given in (5):

(5)	Initial-stressed		Non-initial stressed		Initial unstressed	
a.	*loot*	[lút]	*voluminous*	[vəlúmənəs]	*lugubrious*	[lugúbriəs]
		*[lj͡ut]		*[vəljúmənəs]		*[ljugúbriəs]
b.	*rude*	[rud]	*peruse*	[peruz]	*routine*	[rutin]
		*[rj͡ud]		*[perjuz]		*[rjutin]
c.	*news*	[nuz]	*Menudo*	[mənudoʊ]	*pneumonic*	[numɑnɪk]
		*[nj͡uz]		*[mənj͡udoʊ]		*[nj͡umɑnɪk]

The data in (5) indicate that the diphthong [j͡u] never follows coronal sonorants in stressed or initial syllables. This pattern is notably different from [j͡u] following [m], where it is contrastive with [u]. Many theorists have argued that the lack of forms with tautosyllabic coronal consonant-/j/ sequences is rooted in the obligatory contour principle (OCP, Yip 1991)

In post-tonic syllables, however, there are sequences that appear to be alveolar sonorants followed by [j͡u] (e.g., *menu, volume, erudite*). The argument in this work is that the alveolar sonorant is heterosyllabic with the palatal, and that the palatal glide surfaces as an onset in these syllables, with [u] as the vowel (following Borowsky 1984, 1986, also see Davis & Hammond 1995). For example, the correct syllabification of *menu* is [mɛn.ju]. The phonological motivation for coda syllabification is that the sonorant moves to the coda of the stressed syllable to satisfy a condition on having heavy stressed syllables (Prince 1990).

There are two direct predictions of the coda syllabification account. The first is that American English should not contain forms with coronal sonorant-/j/ sequences if the coda of the stressed syllable is already filled. Thus, the syllabification account correctly predicts the ill-formedness of forms such as *[mɛk.nju]. A corollary of the coda syllabification account is that [j] surfaces as the onset of the post-tonic syllable, and that the [ju] sequence is represented as a CV sequence and not as a diphthong. The prediction generated by this representation is that VBR should not have the same type of difficulty with these sequences, as they are not complex structures like the rising diphthong [j͡u]. This prediction is borne out as well; VBR correctly produces forms such as [mɛn.ju], despite the difficulty with [j͡u] in words such as *cute*.

3.3 Alveolar Obstruents

Previous accounts of the palatal glide in American English which have not focused on the role of [u] have not addressed the behavior of alveolar obstruents preceding [u]. This is not surprising, as there are no words with alveolar obstruents preceding [j]. However, the language-internal data suggest a connection between the behavior of alveolar obstruents and the data discussed above, as alveolar obstruents are neutralized in post-tonic syllables with [u] as the nucleus, surfacing as their alveo-palatal counterparts. The data in (6) show that alveolar and alveo-palatal obstruents contrast when preceding [u] in initial and stressed syllables but only alveo-palatals surface in post-tonic syllables.

(6)	Initial	Stressed	Post-tonic
	suit/shoot	monsoon/prosciutto	*[tɪ.su]/tissue
	Tulane/Chewbacca	cartoon/eschew	*[vɝtu]/virtue

The data presented in (6) demonstrate that when [u] is preceded by an alveolar obstruent, the obstruent must be alveo-palatal in post-tonic syllables. This pattern is part of the larger pattern discussed in this

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this word can be pronounced as *[kǽl.ku.leɪt] or [kǽl.kj͡u.leɪt]; the latter of these pronounciations is well-formed, whereas the former is not.

section: [u] is always preceded by [+pal] in post-tonic syllables. The palatal may surface as a diphthong [j͡u] (section 3.1), a singleton consonant onset (3.2), or an alveo-palatal obstruent (3.3).

3.4 Summary

The data in this section support the claim that the pattern of [j] appearing before [u] is driven by restrictions on the appearance of [u]. In particular, there is a tendency for [u] to be preceded by a [+pal] segment which is mandatory in post-tonic syllables. Table 1 summarizes the data presented in this section, and these data are the basis of the Richness of the Base analysis presented in section 4.

Preceding C	stressed/initial	post-tonic	form of [+pal]	Complex structure?
non-coronal	Cj͡u Cu	Cj͡u *Cu	rising diphthong	Yes
Alveolar sonorant	*Cju Cu	C.ju *Cu	[j] onset	No
Alveolar obstruent	[+alv, +pal, –son]u Cu	[+alv, +pal, –son]u *Cu	alveo-palatal	No

The next section presents an OT account of the data summarized in the table above. The account presented here focuses on the neutralization pattern in post-tonic syllables, and is extended to account for the production pattern of VBR discussed throughout this paper.

4 Richness of the Base account of [u] and [j͡u] in American English

This section presents an OT account of the data discussed above. The presentation of the account is guided by Richness of the Base (Prince & Smolensky 1993/2004), which holds that all possible inputs yield well-formed surface expressions. The discussion of VBR's grammar will be interleaved with the analysis of the American English data.[7]

The work presented here uses positional faithfulness constraints (Beckman 1998) to account for the different patterns in prominent syllables (i.e., stressed and initial) compared with post-tonic syllables, and the different patterns of alveolar sonorants and obstruents is accounted for with sonority-based constraints (based on Gouskova 2002).

4.1 Non-coronal consonants before [u] and [j͡u]

Non-coronal consonants precede either [u] or [j͡u] in initial and stressed syllables, but [j͡u] is required in post-tonic syllables. The account of these data relies on four constraints, given in (7).

(7) a. FAITH-IO-PAL-σ́: [+pal] feature appears in prominent syllables in output *iff* it appears in the input
b. FAITH-IO-PAL-σ: [+pal] feature appears in the output *iff* it appears in the input
c. *RISING: No rising diphthongs (Barlow 1996)
d. M_1: [u] must be preceded by a palatal

The constraints in (7a,b) are correspondence-based (McCarthy & Prince 1995) positional faithfulness constraints (as in Beckman 1998). The specific constraint in (7a) penalizes a lack of correspondence in [pal] features between the input and output in prominent syllables, and the general constraint in (7b) penalizes the lack of correspondence in all syllables. The markedness constraint (7c) prohibits rising diphthongs; this constraint is violated by all output forms containing [j͡u]. The constraint in (7d) is a

[7] Given that VBR is an adult speaker of American English, it is assumed that she has optimized the lexical forms of the language prior to the onset of her impairment (via Lexicon Optimization, as discussed in Prince and Smolensky 1993/2004). Therefore, it is not necessary to provide a Richness of the Base account of her grammar.

markedness constraint violated by forms with [u] not preceded by a palatal; this constraint is not violated by the diphthong [j͡u][8].

Tableaux 1 and 2 depict the optimization for *coot* and *cute* respectively for American English. In each case, the faithful candidate will surface, as the non-faithful candidate commits a fatal violation of the positional faithfulness constraint which outranks each markedness constraint.

T1: *coot* in American English

T1		**kut**	F-σ́	M_1	*RISING	F-σ
	a.	.kj͡út.	*!		*	*
☞	b.	.kút.		*		

T2: *cute* in American English

T2		**kjut**	F-σ́	M_1	*RISING	F-σ
☞	a.	.kj͡út.			*	
	b.	.kút.	*!	*		*

In non-prominent syllables, the candidate with the rising diphthong is optimal, due to the ranking M_1 ≫ *RISING ≫ F-PAL . Tableau 3 depicts the optimization with /kælkuleɪt/ as input, and shows how the non-faithful candidate wins this optimization.

T3: *calculate* in American English

T3		**kælkuleit**	F-σ́	M_1	*RISING	F-σ
☞	a.	.kǽl.kj͡u.leit			*	*
	b.	kǽl.ku.leit		*!		

The same constraints also account for VBR's grammar. As discussed earlier, VBR produces words that contain the rising diphthong with [u] instead of [j͡u]. This corresponds to a re-ranking of the constraints corresponding to an elevation in the relative ranking of *RISING compared to both M_1 and FAITH-IO-PAL-σ́. This ranking causes the candidate with [u] to be the optimal output for an input of /kj͡ut/, as shown in Tableau 4.

T4: *cute* in VBR's grammar

T4		**kj͡ut**	*RISING	F-σ́	M_1	F-σ
	a.	.kj͡út.	*!			
☞	b.	.kút.		*	*	*

Tableau 4 demonstrates that the account of non-coronal-[j͡u] sequences in English also captures the data from the aphasic speaker discussed in section 1. Here the elevation of *RISING forces a faithfulness violation (deletion of the onglide) by the optimal candidate, which does not contain the complex structure associated with the diphthong.[9]

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[8] The fact that M_1 is unnamed is indicative of the tentative nature of this constraint; however, it is clear that there is something that there is a constraint that prefers [u] to be preceded by a palatal, active in American English. One possible grounding for this constraint is that the palatal is necessary as a vehicle for rounding of [u], particularly when it is reduced in post-tonic syllables (Elliott Moreton, *p.c.*).

[9] The full constraint ranking in VBR's grammar is discussed in section 2.2. Tableau 4 collapses across faithfulness constraints, and the candidate [kə.jut] is not shown. As the earlier discussion suggests, this candidate is ruled out by the ranking DEP-σ́-V ≫ MAX-σ́-V. Additional research into other patterns is necessary to determine whether this ranking holds for American English, or whether it is specific to VBR's grammar.

4.2 Alveolar sonorants before [u] and [ju]

Alveolar sonorants are never tautosyllabic with [ju] or [j͡u]. The data presented in section 3.2 argued that alveolar sonorants directly precede [u] in prominent syllables and are heterosyllabic with [j] in post-tonic syllables (e.g., *menu* [mɛ́n.ju]). Alveolar sonorants are never tautosyllabic with the palatal glide or the onglide diphthong. This has been argued to be due to an OCP constraint (Yip 1991). The coda syllabification account requires a constraint that motivates the sonorant to move into the coda of the previous syllable (STRESS-TO-WEIGHT). Importantly, this constraint must outrank a constraint on sonority sequencing that disprefers a rise in sonority at the syllable boundary. These constraints are defined in (8).

(8) a. OCP(ALV-PAL): do not have [+alveolar][+palatal] sequences
    b. STRESS-TO-WEIGHT: stressed syllables are heavy (Prince 1990, Kager 1999)
    c. DISTANCE X: do not change sonority by distance of X at syllable boundary (Gouskova 2002)

The DISTANCE X constraint is violated by changing in sonority by a certain distance at the syllable boundary. The distance is computed by the change in sonority. I adopt Gouskova's sonority scale in this work, given in (9):

(9) Sonority scale: glide > r > l > nasal > voiced fricative > voiced obstruent > voiceless fricative voiceless obstruent

The ordinal scale in (9) has the most sonorous elements on the left and the least sonorant on the right, and the distance between the margins at the syllable boundary is computed based on this scale. For example, at a syllable boundary with [n] in the coda and [j] in the onset (as in [mɛ́n.ju]), there is a change of +3, which violates the constraint DISTANCE(+3). The DISTANCE constraints project a universal ranking: DISTANCE (X) ≫ DISTANCE (Y) for all X ≫ Y.

Tableau 5 depicts the optimization for *menu* with /mɛnu/ as input. The optimal output is candidate (c), with [n] in the coda of the stressed syllable and [j] in the onset of the post-tonic syllable.

T5: Coda syllabification of alveolar sonorant following stressed syllable

T5	**mɛnu**	OCP	STRTOWT	DIST(+3)	M_1	*RISING	F-σ
a.	.mɛ́.n͡ju.	*!	*			*	*
b.	.mɛ́.nu.		*!		*		
☞ c.	.mɛ́n.ju.			*			*
d.	.mɛ́n.u.			*	*!		

The candidate with the rising diphthong (a) is ruled out in these cases by the high-ranked OCP constraint. Candidate (b), which contains a faithful mapping with [n] in the onset of the post-tonic syllable, incurs a fatal violation of STRESS-TO-WEIGHT. Candidate (d) is also a faithful mapping which satisfies STRESS-TO-WEIGHT, but this candidate is ruled out due to a fatal violation of M_1.

As discussed above, coronal sonorants directly precede [u] in prominent syllables. Tableau 6 depicts the optimization for *Menudo,* with an input of /mənjudoʊ/.

T6: Onset syllabification of alveolar sonorant in stressed syllable

T6	**mənjudoʊ**	OCP	STRTOWT	DIST(+3)	F-σ́	M_1	*RISING	F-σ
a.	.mə.n͡júd.oʊ.	*!			*		*	
☞ b.	.mə.núd.oʊ.					*		*
c.	.mən.júd.oʊ.			*!	*			
d.	.mən.úd.oʊ.			*!				*

In the optimization in T6, candidate (a) – containing a rising diphthong – is ruled out due to a fatal violation of the OCP constraint. The output forms have stress on the penultimate syllable which contains the [u], so STRESS-TO-WEIGHT is not violated by these candidates. Candidates (c) and (d) each incur fatal violations the DIST constraint[10] which crucially outranks M_1, violated by the most harmonic output candidate (b).

4.3 *Alveolar obstruents and alveo-palatal obstruents before [u]*

As discussed above, both alveolar obstruents and their alveo-palatal counterparts are licensed before [u] in prominent syllables, but only the alveo-palatal obstruents appear before [u] in post-tonic syllables. The account of this pattern uses the same constraints as discussed above. The critical difference between the account of alveolar sonorants and alveolar obstruents is the violation of higher-ranked DIST constraint by a candidate with an obstruent coda and a glide onset. This is shown in Tableau 7, which depicts the optimization for an input of /tɪsu/ which yields the unfaithful parse [tɪ.ʃu] with an alveo-palatal fricative [ʃ] in place of the alveolar fricative [s] in the output.

Tableau 7: Palatalization of alveolar obstruent in post-tonic syllable

T7	**tɪsu**	OCP	DIST(+6)	STRTOWT	DIST(+3)	M_1	*RISING	F-σ
a.	.tɪ.sj͡u.	*!					*	*
b.	.tɪ́s.ju.		*!					*
☞ c.	.tɪ́.ʃu.			*				*
d.	.tɪ́.su.			*		*!		

In Tableau 7, candidate (c) is the optimal output. Candidate (a) incurs a fatal violation of the OCP constraint, and candidate (b) violates DIST(+6), which crucially outranks STRESS-TO-WEIGHT. Candidate (c) is preferred to candidate (d) as the latter fatally violates M_1.

In prominent syllables, forms with alveolar obstruents surface faithfully. The optimization is similar to that shown in Tableau 6 for the alveolar sonorants and is not repeated here.

4.4 Comparison to other analyses

This section presented a Richness of the Base OT account of the appearance of [j], [u], and [j͡u] in post-consonantal contexts in American English. Further, it was shown that the grammar of aphasic speaker VBR can easily be accounted for with the same set of constraints, by positing an elevation of constraints in the *COMPLEX family (notably *RISING in this analysis).

Previous accounts of these data in rule-based frameworks have posited changes to these forms at different points in the derivation. For example, Chomsky and Halle (1968, also see Halle & Mohanan 1985) argued for a /j/-insertion rule after non-coronals and before a back high unrounded vowel in the underlying representation. A rule that rounded the vowel was argued to apply after /j/-insertion. Davis and Hammond (1995) argued that /j͡u/ is an underlying diphthong that undergoes a gliding process prior to surface expression. As mentioned in footnote 3, this type of argumentation is not possible in the framework of OT used here, where surface differences cannot be explained via restrictions on underlying representations. Barlow (2001) presents an analysis of forms with the diphthong [j͡u], but her analysis does not capture the range of phenomena discussed here.[11]

[10] Candidate (d) in T6 actually violates a higher ranked version of DIST as well as ONSET; neither of these constraints are shown in this tableau as they do not effect the outcome here.

[11] Barlow (2001) argues that there is variation in how American English speakers represent the sound structure in a word such as *cute*, with some speakers treating [j͡u] as a diphthong as argued here, and others treating [kj] as an onset cluster. The work presented in this paper focuses on the primary pattern in which [j͡u] is represented as a diphthong. See Barlow's (2001) paper for an extensive discussion of the individual differences in performance in a language game task.

5 Implications for grammar and aphasia

The work presented here broadly supports Jakobson's (1941/1968) assertion that language loss in aphasia is constrained by the same principles of linguistic complexity that govern the distribution of linguistic elements cross-linguistically and language acquisition. In particular, VBR's grammar can be accounted for using the same grammatical principles that account for the language-internal pattern. In this case, constraints in the *COMPLEX family have been elevated with respect to both faithfulness constraints and other markedness constraints. Additional studies of this nature are necessary to determine whether other markedness principles are active in constraining aphasic speech errors other than phonological complexity operationally defined as structures violating *COMPLEX constraints.

This work also demonstrates how patterns of aphasic speech errors can be used as a type of language-external evidence to investigate sound structure representation. In particular, aphasic data can be combined with language-internal data to support (or reject) particular representational claims. In this case, the evidence from aphasic speaker VBR supported the claim that tautosyllabic consonant-/j/-/u/ sequences contain a diphthong ([j͡u]) and not a cluster (at least for some speakers; see footnote 11). VBR's data also support the claim that alveolar sonorants preceding /ju/ are syllabified in the coda of the stressed syllable, and not the onset of the post-tonic syllable. As a formal theory of markedness, OT provides a mechanism to account for the results of the investigation, capturing both the grammar of American English and the grammar of VBR by re-ranking the same constraints.

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